Journal of Human Kinetics volume 69/2019, 137-147 DOI: 10.2478/hukin-2019-0021 137
**Section II - Exercise Physiology & Sports Medicine**

sciendo

# International Standards for the 3-Minute Burpee Test: High-Intensity Motor Performance

*by*

*Robert Podstawski[1], Piotr Markowski[2], Cain C. T. Clark[3], Dariusz Choszcz[2], Ferenc Ihász[4], Stanimir Stojiljković[5], Piotr Gronek[6]*

*The aim of this study was to develop international standards for evaluating strength endurance with the use of the 3-Minute Burpee Test. The results of 3862 women (Poland – 2502, Great Britain – 500, Hungary – 412, Serbia – 448) and 5971 men (Poland – 4517, Great Britain – 500, Hungary – 451, Serbia – 503) aged 18-25 (mean age of 20.36 ± 0.94 and 20.05 ± 1.25 y, respectively) were collated between 2004 and 2018. The students' strength endurance was evaluated in the 3-Minute Burpee Test. The results were expressed on a uniform scale with the 3-sigma rule which was used to develop the T-score scale for the 3-Minute Burpee Test. Men completed 56.69 cycles/3 min and women – 48.84/3 min on average. The best male participant completed 82 burpees, and the best female participant – 73 burpees. The majority of male and female participants (66.71% and 68.18%, respectively) were characterized by average strength endurance in the 3-Minute Burpee Test (range of scores: 47-66 and 37-60 cycles/3 min, respectively). Very good strength endurance (76-85 and 72-83 cycles/3 min, respectively) was noted in the smallest percentage of male and female participants (0.52% and 0.26%, respectively). Similar studies should be carried out in other countries and in different age groups to develop objective international classification standards for variously-aged individuals.*

***Key words**: strength endurance, extreme effort, 3-MBT, norms.*

## Introduction

Cardiorespiratory endurance and strength abilities are the basic components of physical fitness that contribute to significant health benefits. There is ample scientific evidence to suggest that regular aerobic and resistance training is a highly effective strategy for managing and improving physical fitness, preventing fatigue and motivating individuals to pursue their fitness goals (Klika and Jordan, 2013). These exercise strategies have to be safe, effective and efficient in order to deliver tangible results for time-constrained individuals, who should be able to perform the program in any location without the need for dedicated equipment (Klika and Jordan, 2013).

Conventionally, resistance training is not combined with aerobic training and is usually performed on two or three consecutive days of the week. According to the guidelines of the American College of Sports Medicine (ACSM), every resistance exercise should be performed in sets of 8-12 repetitions for each major muscle group with intensity of 40-80% 1 RM. The

[1] - *University of Warmia and Mazury in Olsztyn, Faculty of Environmental Sciences, Department of Tourism, Recreation and Ecology, Olsztyn, Poland.*
[2] - *Department of Heavy Duty Machines and Research Methodology, Faculty of Technical Sciences, University of Warmia and Mazury in Olsztyn, Olsztyn, Poland.*
[3] - *Faculty of Health and Life Sciences, Coventry University, Coventry, CV1 5FB, U.K.*
[4] - *Faculty of Psychology and Pedagogy, Institute of Sports Sciences, Eötvös Lóránd University, Szombathely, Hungary.*
[5] - *Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Republic of Serbia.*
[6] - *Department of Dance and Gymnastics of the University of Physical Education in Poznań, Poznań, Poland.*

*Authors submitted their contribution to the article to the editorial board.*
*Accepted for printing in the Journal of Human Kinetics vol. 69/2019 in September 2019.*

recommended recovery time between sets is two to three minutes. Each muscle group should be exercised in two to four sets (Klika and Jordan, 2013). According to standard guidelines, weekly aerobic training should involve 150 minutes of moderate intensity exercise (46 to 63% of maximal oxygen uptake, $VO_{2max}$) for 30 to 60 minutes per session and/or 75 minutes of vigorous intensity exercise (64 to 90% of $VO_{2max}$) for 20 to 60 minutes per session (Klika and Jordan, 2013).

Despite the unequivocal effectiveness of cardiorespiratory endurance and resistance training (Maiorana et al., 2000), the main factors that discourage individuals from pursuing these types of exercise are the considerable length of training sessions, as well as the limitations associated with the structure and character of these two different training regimes (Klika and Jordan, 2013). High-intensity circuit training (HICT), where body weight is used for resistance, offers a practical solution to the above problem.

***High-intensity circuit training (HICT)***

High-intensity circuit training (HICT) that relies on body weight for resistance appears to be an effective solution for cardiorespiratory and resistance training. According to the Top 20 Worldwide Fitness Trends for 2018, HICT is the most popular form of exercise in fitness clubs (Thompson, 2017). The idea behind HICT is not new; however, this type of training is gaining popularity, which can be attributed to its efficiency and practicality in a fast-paced society. Aerobic and resistance training is combined with short rest intervals to deliver considerable health benefits within a shorter period of time than traditional training (Gibala et al., 2006). In HICT, body weight is used for resistance, and it eliminates the need for equipment and facilities. For this reason, HICT exercises are often used in high-intensity interval training (HIIT) which is also an optimal workout for improving metabolic and cardiovascular functions (Alonso-Fernandez et al., 2017). Therefore, HICT is a time-efficient strategy which facilitates training adaptation to a similar extent as competitive training (Martins et al., 2016). HICT is highly effective in team sports (Alonso-Fernandez et al., 2017), most combat sports (Podstawski et al., 2016a), functional training such as cross-fit and water sports (Claudino et al., 2018). Fan et al. (2013) demonstrated that high-intensity exercises performed for both less and more than 10 minutes decreased the body mass index and lowered the risk of obesity. The obesity risk was decreased by 5% in women and 2% in men per every minute of high-intensity exercise. There is also evidence to indicate that HICT improves exercise capacity in individuals suffering from chronic or temporary health conditions (Claudino et al., 2018).

Physiological responses to training are significantly influenced by the intensity of exercise and duration of work intervals (Astrand et al., 2003). According to recent research, vigorous exercise (at 80% of $VO_{2max}$) provides greater benefits than moderate exercise (at 60% of $VO_{2max}$) (Di Pietro et al., 2006). Individuals can decrease their reliance on equipment and facilities by using their body weight for resistance. Therefore, HICT is a time-efficient strategy for training adaptation, which is as effective as competitive training (Martins et al., 2016). Based on the length of work intervals, HICT can be classified as; long (3-15 min), moderate (1-3 min) and short HICT (10 s – 1 min) (Guiraud et al., 2012). The intensity and duration of work intervals generally determine physiological adaptation and the benefits of high intensity training (Alonzo-Fernandez et al., 2017; Di Pietro et al., 2006).

The effectiveness of HICT should be evaluated with the use of a valid and reliable test that quickly and safely provides reliable information on participants' strength endurance. The 3-Minute Burpee Test (3-MBT) has been designed to evaluate strength endurance during bouts of extreme physical activity. The 3-MBT is a classic example of an exercise during which the participant has to complete the highest possible number of cycles involving squats, back kicks and the plank position on extended arms during several minutes of extreme physical exertion.

***Brief History***

The main objective of the test is to measure agility and coordination. It consists of a series of "burpees" – physical exercises which begin with a squat thrust and end in a standing position. The Burpee test is immensely popular among athletes, and various versions of the test have been developed. The modified versions of the test differ in spatiotemporal structure, and every variant can be used independently to evaluate different motor abilities. The following

versions of the Burpee test have been described in the literature:

- 10 s Burpee Test – the original Burpee test which is used in the McCloy Physical Fitness Test (Mc Cloy and Young, 1954),
- 20 s Burpee Test – used in the "Fitness for health" test (Podstawski et al., 2016a),
- 30 s Burpee Test – used by Denisiuk (Podstawski et al., 2016a) in the Motor Fitness Test for girls, and by Sakamaki (1983).
- 60 s Burpee Test – used by Denisiuk (Podstawski et al., 2016a) in the Motor Fitness Test for boys,
- 3-minute Burpee Test – used to evaluate elementary school students, university students and early education teachers (Podstawski et al., 2013, 2014, 2015).

***Characteristics of the 3-Minute Burpee Test***

The classification standards for the 3-MBT have been developed in a series of rigorous tests to determine the criteria for evaluating the test's validity and reliability. The conducted tests have confirmed the validity of the 3-MBT and its usefulness for accurate assessments of strength endurance in young women. In a group of female university students, the values of the reliability coefficients between successive trials for the 3-MBT ranged from very low (satisfactory for individual assessment and for group comparison) to perfect reliability (Podstawski et al., 2016b). Previous research has demonstrated the usefulness of the 3-MBT for evaluating strength endurance in various age groups (Podstawski et al., 2015). The author's previous study revealed that body mass, the BMI and body weight were significantly negatively correlated with the number of completed burpee cycles. The 3-MBT is a highly vigorous workout which raised the heart rate (HR) to an average of 181.92 $b \cdot min^{-1}$ in the evaluated group of female university students (Podstawski et al., 2016a).

The aim of this study was to develop international standards for evaluating strength endurance of individuals aged 19-25 years with the use of the 3-Minute Burpee Test (3-MBT).

## Methods

*Participants*

The presented classification standards were developed in a study conducted in 2004-2018 on a large, representative and random population sample of 3862 women (Poland – 2502, Great Britain – 500, Hungary – 412, Serbia – 448) and 5971 men (Poland – 4517, Great Britain – 500, Hungary – 451, Serbia – 503) aged 18-25 years (mean age: women – 20.36 ± 0.94 years, men – 20.05 ± 1.25 years). The study was conducted at the University of Warmia and Mazury in Olsztyn, the University of Physical Education in Poznań (Poland), the University Centre Hartpury (Great Britain), the University of Belgrade (Serbia) and the Eötvös Lórándin University in Szombathely (Hungary). The use of international classification standards ensured the objectivity of the study.

*Procedures*

The research was performed in compliance with the Declaration of Helsinki and upon the prior consent of the Bioethical Committee and the authorities of the University of Warmia and Mazury in Olsztyn. All participants gave their written consent to take part in the study.

*Measurements*

Body height measurements were performed to the nearest 0.1 mm on a WB-150 medical scale with a stadiometer and a Martin anthropometer based on standard guidelines. Body mass was determined to the nearest 0.1 kg, and the results were used to calculate the participants' BMI. Strength endurance was evaluated during the 3-MBT (Podstawski et al., 2013). During initial meetings before the study, participants performed one 3-MBT weekly. Five trials of the 3-MBT were completed to guarantee reliable results (Podstawski et al., 2016b). Before the test, participants were instructed on how to perform the 3-MBT correctly, and they were allowed time to practice. The test was preceded by an active warm-up (10 minutes). The warm-up routine included jogging, general and specific resistance and stretching exercises.

*The correct technique for performing the 3-Minute Burpee test*

Strength endurance was evaluated based on the number of burpee cycles completed in 3 minutes. The stages of the 3-MBT are presented in Figure 1

**Stage I** Begin in a standing position (Figure 1a) and move into a supported squat with both hands on the ground (Figure 1b).

**Stage II** From a supported squat (Figure 1b), kick your feet back (Figure 1c) into a plank with

arms extended (Figure 1d).

**Stage III** Return from the plank position (Figure 1d) to a supported squat (Figure 1e).

**Stage IV** Return to a standing position (Figure 1j), extend your arms over the head and clap your hands (Figures: 1f, 1g, 1h, 1i).

The participants repeated the cycle in the specified order as many times as possible in a given time limit (3 minutes).

**Comments:** The plank position should be maintained on extended arms without arching the back, but an exception can be made for individuals without adequate upper body strength. The legs should be fully extended in the plank position. A cycle was not counted when particular stages were not correctly performed.

*Statistical analysis*

Minimum, maximum and average values, median values and standard deviations were determined during a statistical analysis. The 3-sigma rule was applied to express the results of the motor fitness test on a uniform scale and to develop the T-score scale for the 3-MBT (Table 1).

The obtained results were used to categorize the level of fitness of the participants. They can also be used to monitor changes in strength endurance of the studied population.

## Results

The data describing male and female participants are presented in Table 2, the participants' scores are shown in Table 3, and the international classification standards for the 3-MBT are provided in Table 4.

***** Table 2 about here *****

Male students performed 56.69 cycles/3 min, and female students – 48.84 cycles/3 min on average. The best male performer completed 82 burpees, and the best female performer – 73 burpees. Male participants were heavier and taller than their female counterparts. The BMI was within the norm for both male and female participants (men – 20.05 kg/m$^2$, women – 20.36 kg/m$^2$) (Table 2).

The results of the 3-MBT were used to evaluate strength endurance of individuals aged 18-25 years on a 5-point grading scale with the use of the discussed classification standards. The scores were presented in table format for evaluation or self-evaluation and to cross-reference the results achieved in same-sex groups. The majority of male (66.71%) and female (68.18%) participants were characterized by average strength endurance. Men completed 47-66 cycles/3 min, and women – 37-60 cycles/3 min. Very good strength endurance (76-85 and 72-83 cycles/3 min, respectively) was noted in the smallest percentage of male and female participants (0.52% and 0.26%, respectively) (Table 3).

The 3-MBT scores were converted to a T-scale of 1 to 100 to evaluate participants' strength endurance. In this approach, the existing motor fitness test batteries (such as Eurofit) can be expanded to include the 3-MBT. A 5-point grading scale allows for a quick assessment of participants' strength endurance as poor, weak, good, very good or excellent. The results scored by female and male participants in the 3-MBT were expressed on a uniform 5-point grading scale with the use of 3-sigma rule. Participants who scored below the minimum threshold of the first interval were awarded 1 point, whereas the participants who scored above the maximum threshold of the fifth interval were awarded 100 points on the scale (Table 4).

## Discussion

The aim of this study was to develop international standards for evaluating strength endurance with the use of the 3-MBT. To this end, international standards for the 3-MBT were ascertained and uniformly presented using robust statistical procedures.

The majority of the studied participants were characterized by average strength endurance (68.18% of women completed 37-60 cycles/3min, and 66.71% of men completed 47-66 cycles/3 min). In a study comparing strength endurance of early education teachers and first-year female university students vs. pre-school children and elementary school students, 73.27% of the evaluated women achieved average results, but their scores comprised a smaller range of values (36-50 cycles/3 min), probably due to a much smaller sample size (520 women) (Podstawski et al., 2014).

**Table 1**

*Score scale for evaluating strength endurance in the 3-MBT*

| Physical fitness level | Standard results | T-scale |
|---|---|---|
| Very good | >X + 2SD ÷ < X + 3SD | 81 ÷100 |
| Good | >X+ SD ÷ < X + 2SD | 61 ÷80 |
| Average | X – SD ÷ X + SD | 41 ÷60 |
| Poor | <X – 2SD÷ > X - SD | 21 ÷40 |
| Very poor | < X – 3SD ÷ > X – 2SD | 1 ÷20 |

**Table 2**

*Body mass, height and BMI in the studied population*

| Gender | [No] | Age [years] | Body mass [kg] | Body height [cm] | BMI [kg/m²] | No. of cycles | T-scale |
|---|---|---|---|---|---|---|---|
| | | Mean ± stand. dev. (min÷max) | | | | | |
| Men | 5971 | 20.05 ± 1.25 (19÷25) | 77.20 ± 9.77 (55.0÷130.1) | 180.99 ± 6.08 (161.4÷203.0) | 23.56 ± 2.71 (17.1 ÷ 37.2) | 56.69 ± 9.52 (24.0÷82.0) | 50.41 ± 13.15 (1.0÷100.0) |
| Women | 3862 | 20.36 ± 0.94 (19.0÷24.0) | 60.21 ± 8.92 (40.6÷101.3) | 165.1 ± 6.36 (139.8÷187.2) | 22.13 ± 3.41 (15.1÷38.2) | 48.84 ± 11.43 (10.0÷73.0) | 50.87 ± 12.97 (1.0÷100.0) |

**Table 3**

*Five-point grading scale for evaluating female and male participants*

| Level | Tolerance range | | N | % | Average range | |
|---|---|---|---|---|---|---|
| | Cycles | Points | | | Cycles | Points |
| | | | Men | | | |
| Very poor | 28÷38* | 1÷20 | 272 | 4.56 | 34 | 13.6 |
| Poor | 38÷47 | 21÷40 | 775 | 12.98 | 43 | 30.9 |
| Average | 47÷66 | 41÷60 | 3983 | 66.71 | 58 | 52.7 |
| Good | 66÷76 | 61÷80 | 910 | 15.24 | 68 | 66.0 |
| Very good | 76÷85** | 81÷100 | 31 | 0.52 | 77 | 82.9 |
| | | | Women | | | |
| Very poor | 15÷26* | 1÷20 | 145 | 3.75 | 20 | 10.4 |
| Poor | 26÷37 | 21÷40 | 404 | 10.46 | 32 | 31.8 |
| Average | 37÷60 | 41÷60 | 2633 | 68.18 | 49 | 51.6 |
| Good | 60÷72 | 61÷80 | 670 | 17.35 | 64 | 67.1 |
| Very good | 72÷83** | 81÷100 | 10 | 0.26 | 72 | 81.3 |

**- a score below the minimum value of the first interval is equivalent to 1 point on the scale.*

***- a score above the maximum value of the fifth interval is equivalent to 100 points on the scale.*

**Table 4**

*International classification standards based on the T-scale for men and women aged 18-25 years*

| Cycles | T-scale | | Cycles | T-scale | | Cycles | T-scale | |
|---|---|---|---|---|---|---|---|---|
| | Men | Women | | Men | Women | | Men | |
| **11** | 1 | 1 | **36** | 18 | 37 | **61** | 56 | 63 |
| **12** | 1 | 1 | **37** | 20 | 41 | **62** | 57 | 64 |
| **13** | 1 | 1 | **38** | 21 | 42 | **63** | 58 | 66 |
| **14** | 1 | 1 | **39** | 23 | 43 | **64** | 59 | 68 |
| **15** | 1 | 1 | **40** | 25 | 44 | **65** | 60 | 70 |
| **16** | 1 | 3 | **41** | 27 | 44 | **66** | 61 | 71 |
| **17** | 1 | 4 | **42** | 29 | 45 | **67** | 63 | 73 |
| **18** | 1 | 6 | **43** | 32 | 46 | **68** | 65 | 75 |
| **19** | 1 | 8 | **44** | 34 | 47 | **69** | 67 | 77 |
| **20** | 1 | 10 | **45** | 36 | 48 | **70** | 69 | 78 |
| **21** | 1 | 11 | **46** | 38 | 49 | **71** | 72 | 80 |
| **22** | 1 | 13 | **47** | 41 | 50 | **72** | 74 | 81 |
| **23** | 1 | 15 | **48** | 42 | 51 | **73** | 76 | 83 |
| **24** | 1 | 17 | **49** | 43 | 52 | **74** | 78 | 84 |
| **25** | 1 | 18 | **50** | 44 | 52 | **75** | 80 | 86 |
| **26** | 1 | 20 | **51** | 45 | 53 | **76** | 81 | 88 |
| **27** | 1 | 21 | **52** | 46 | 54 | **77** | 83 | 90 |
| **28** | 1 | 23 | **53** | 47 | 55 | **78** | 85 | 91 |
| **29** | 3 | 24 | **54** | 48 | 56 | **79** | 87 | 93 |
| **30** | 5 | 26 | **55** | 49 | 57 | **80** | 89 | 95 |
| **31** | 7 | 28 | **56** | 50 | 58 | **81** | 92 | 97 |
| **32** | 9 | 30 | **57** | 52 | 58 | **82** | 94 | 98 |
| **33** | 12 | 31 | **58** | 53 | 59 | **83** | 96 | 100 |
| **34** | 14 | 33 | **59** | 54 | 60 | **84** | 98 | 100 |
| **35** | 16 | 35 | **60** | 55 | 61 | **85** | 100 | 100 |

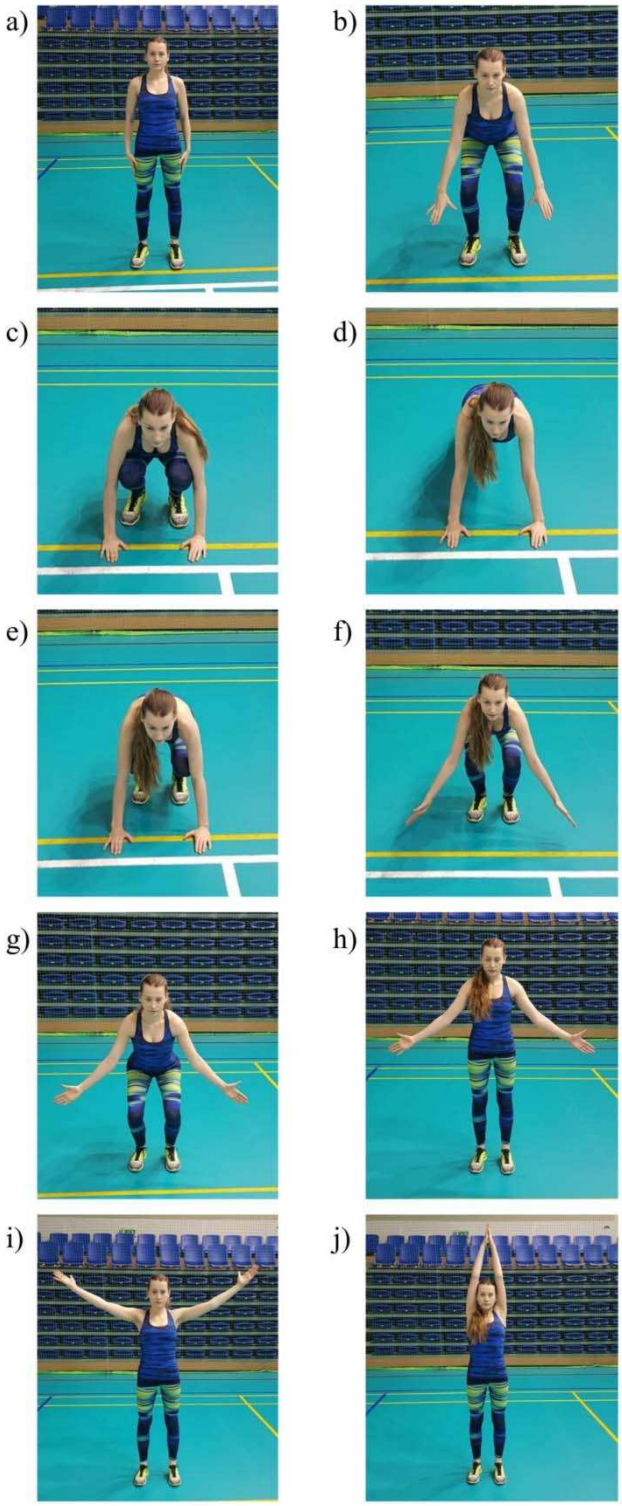


**Figure 1**

*Individual stages of the 3-Minute Burpee test – front view.*

Early education teachers scored significantly lower ($p < 0.001$) than first-year female university students and, surprisingly, than second and third grade girls and boys, respectively (all $p < 0.05$). Siska and Brodani (2017) relied on the 3-MBT in 3 x 3 min sets, with a one-minute rest interval in between (the timing was identical to a boxing match), to test Slovak elite athletes and kickboxers. They reported an average HR of 160 bpm, which decreased by 24 bpm during the rest interval. In the second set, the average HR increased to 163 bpm, and subsequently decreased to 135 bpm during the rest interval. The highest HR of 164 bpm was noted in the third set, which represented 93.18% of the maximum value measured in athletes. The results reported in Slovak athletes were below those noted in female university students (181.92 $b \cdot min^{-1}$), likely because the students had only completed a single 3-minute trial (Podstawski et al., 2016a). Moreover, the athletes' blood lactate concentration reached 14.1 mmol in the fourth minute after the exercise bout, and it decreased to 8.6 mmol in the 15th minute of recovery. With regard to internal responses to exercise, blood lactate concentration and HR values noted by Siska and Brodani (2017) were similar to those reported by other authors for specific boxing exercises, sparring or competition. According to the cited authors, the 3-MBT is a useful tool for both sports training and fitness evaluation.

Strength endurance of university students was also evaluated based on the results of 500 m and 1000 m rows on a rowing ergometer. On average, male participants completed the 500 m row in 111.3 ± 10.75 s (Choszcz et al., 2012), and female students completed the 500 m row in 145.7 ± 10.22 s (Podstawski et al., 2014) while the 1000 m row in 280.1 ± 19.49 s (Podstawski et al., 2012). However, the samples in the above studies were too small to develop classification standards.

Strength endurance is frequently evaluated in martial arts, such as judo and ju-jitsu, and is based on the number of completed sit-ups and bent arm hang scores in bar motor tests (Pietraszewska et al., 2014). However, both tests involve only segmental rather than global measurements including all body parts. According to some authors, strength endurance of abdominal muscles is difficult to assess in athletes because, in most studies, the number of completed sit-ups is measured in a 1-minute bout (Vidal Andreato et al., 2011). Contextually, such tests do not assess strength endurance because 80% of the energy in the first minute of exercise is drawn from anaerobic processes, and only 20% of the energy is drawn from aerobic processes, whereas in typical endurance tests, physical effort should be continued for at least 4-5 minutes at an intensity corresponding to 60-80% of individualized $VO_{2max}$ (Astrand et al., 2003). Therefore, the discussed variant of the 3-MBT not only measures endurance, but also strength endurance. Moreover, the analyzed variant assesses strength endurance more accurately than its 30 s (Sakamaki, 1983), and 60 s (Podstawski et al., 2013) version used in other studies. Podstawski et al. (2013) previously demonstrated, in a study conducted among female university students, that anthropometric features indicative of overweight and obesity, including body mass and the BMI, exerted a negative influence on strength endurance measured by the 3-MBT. The results of the 3-MBT are consistent with the findings of other authors who concluded that body mass was the most significant anthropometric variable which deleteriously impacted endurance, relative strength capacity and performance, respectively (Podstawski et al., 2012). Studies involving the bar hang test revealed that greater body mass negatively correlated with strength endurance of judo and ju-jitsu athletes (Pietraszewska et al., 2014). The bent arm hang test was rationalized for judo and ju-jitsu athletes considering that well-developed arm and shoulder girdle muscles contribute to effective performance of judo techniques (Vidal Andreato et al., 2011). The discussed test also partially measures strength endurance of the wrist. In sports such as judo and ju-jitsu, a competitor holds the opponent by the clothing (judogi) for longer duration, therefore, handgrip strength is crucial during hand-to-hand combat (Vidal Andreato et al., 2011).

A prominent feature of the 3-MBT is that it can be efficaciously used in physical activity programs and functional training; for instance, in physical activity programs, strength endurance exercises elicit positive adaptations of anthropometric variables (significant decreases in body mass, the BMI, waist and hip circumference), body composition (significant

increases in total lean body mass and total fat-free mass with simultaneous significant decreases in total body fat and total body fat content), physical capacity, cardiorespiratory fitness (significant increases in $VO_{2Peak}$, $WR_{max}$, TTE and WRvt) and circulatory variables (decreases in resting DBP, resting SBP and resting HR) in obese individuals (Moraes et al., 2012). Sanal et al. (2013) evaluated the effects of strength endurance training in obese participants and observed that strength endurance exercises reduced trunk fat content in men, and leg fat content in women. Willis et al. (2012) demonstrated that anaerobic strength endurance exercises were more effective than aerobic endurance exercises in decreasing total body fat content and increasing lean body mass and total fat-free mass.

In functional training, the 3-MBT could be applied to protect athletes (for example, soccer and rugby players) against injuries, in particular hamstring strain injuries (HSI), which are prevalent in professional sports, accounting for 12-26% of all injuries in sprint dominated sports, and are a major cause of absence in both training and competition (Ekstrand et al., 2011). Matthews et al. (2017) demonstrated that complex training which aims to develop muscular endurance and maximum strength, has injury preventive potential, by significant improvements in the post-fatigue torque angle profile, and reducing eccentric hamstring torque at longer muscle lengths. Ferrauti et al. (2010) reported that two concurrent strength training sessions per week (combination of high intensity training for the lower limbs and strength endurance training for the trunk muscles) increased muscle strength, and, importantly, did not impair running performance or running economy among recreational marathon runners.

## Conclusions

The majority of university students (nearly 70% of female and male students) aged 18-25 years were characterized by average strength endurance in the 3-MBT. Very good strength endurance was noted in less than 1% of the evaluated females and males. Testing standards should be regularly revised and updated to guarantee and maintain maximum reliability. The authors of the present study, therefore, suggest that, following development of the classification standards for the 3-MBT, this test can be operationally deployed to determine strength endurance of individuals from different age groups and different countries. The obtained scores will facilitate the development of classification standards for different age groups and will expand the international database.

## References

Alonso-Fernandez D, Lima-Correra F, Gutierrez-Sánchez Á, Abadia-Garcia de Vicuńa O. Effects of a high-intensity interval training protocol based on functional exercises on performance and body composition in handball female players. *JHSE*, 2017; 12(4): 1186-1198. Doi: 10.14198/jhse.2017.124.05

Astrand PO, Rodahl K, Dahl HA, Strömme SB. *Textbook of Work Physiology. Physiological Bases of Exercise*. Fourth Edition. Ill, Human Kinetics; 2003

Choszcz D, Podstawski R, Konopka D. Modeling of anthropometric determinants of rowing ergometer performance on a distance of 500 meters for physically inactive males. *J Phys Ed Sport*, 2012; 12(3): 274-283

Claudino JG, Gabbett TJ, Bourgeois F, de Sá Souza H, Miranda RCh, Mezêncio B, Soncin R, Cardoso Filho CA, Bottaro M, Hernandez AJ, Amadio AC, Serrão JC. CrossFit Overview: Systematic Review and Meta-Analysis. *Sports Med Open*, 2018; 4: 11. doi: 10.1186/s40798-018-0124-5

Di Pietro L, Dziura J, Yeekel CW, Neufer PD. Exercise and improved insulin sensitivity in older women: evidence of the enduring benefits of higher intensity training. *J Appl Physiol*, 2006; 100(1): 142-9

Ekstrand J, Hagglund M, Walden M. Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med*, 2001; 39(6): 1226-1232

Fan JX, Brown BB, Hanson H, Kowaleski-Jones L, Smith KR, Zick CD. Moderate to vigorous physical activity and weight outcomes: does every minute count? *Am J Health Promot*, 2013; 28(1): 41-49

Ferrauti A, Bergermann M, Fernandez-Fernandez J. Effects of a concurrent strength and endurance training on running performance and running economy in recreational marathon runners. *J Strength Cond Res*, 2010; 24(10): 2770–2778

Gibala MJ, Little JP, Essen MV, Wilkin GP, Burgomaster KA, Safdar A, Raha S, Tarnopolsky MA. Short term sprint interval versus traditional endurance training: similar initial adaptation in human skeletal muscle and exercise performance. *J Physiol*, 2006; 575(3): 901-911. DOI: 10.1113/jphysiol.2006.112094

Guiraud T, Gremeaux V, Juneau M, Bosquet, L. High intensity interval training in cardiac rehabilitation. *Sports Med*, 2012; 42(7): 587-605. https://doi.org/10.2165/11631910

Klika B, Jordan C. High-intensity circuit training using body weight: Maximum results with minimal investment. *ACSM's Health Fitness J*, 2013; 17(3): 8-13

Maiorana A, O'Driscoll G, Cheetham C, Collis J, Goodman C, Rankin S, Taylor R, Green D. combined aerobic and resistance exercise training improves functional capacity and strength in CHF. *J Appl Physiol*, 2000; 88: 1565-1570

Martins C, Kazakova I, Ludviksen M, Mehus I, Wisloff U, Kulseng B, Morgan L, King N. High-intensity training and isocaloric moderate-intensity continuous training result in similar improvements in body composition and fitness in obese individuals. *Int J Sport Nutr Exerc Met*, 2016; 26: 197-204. https://doi.org/10.1123/ijsnem.2015-0078

Matthews MJ, Heron K, Todd S, Tomlinson A, Jones P, Delextrat AD. Cohen DD. Strength and endurance training reduces the loss of eccentric hamstring torque observed after soccer specific fatigue. *Phys Ther Sport*, 2017; 25: 2539-46

Mc Cloy CH, Young MD. *Tests and measurement in health and physical education*. New York: Appleton-Century-Crofts; 1954

Moraes WM, Souza PR, Pinheiro MH, Irigoyen MC, Medeiros A, Koike MK: Exercise training program based on minimum weekly frequencies: effects on blood pressure and physical fitness in elderly hypertensive patients. *Rev Bras Fisioter*, 2012; 16: 114-121

Pietraszewska J, Burdukiewicz A, Stachoń A, Witkowski K, Andrzejewska J, Stefaniak T, Chromik K, Harmaciński D, Maśliński J. Is the level of static and strength endurance a reflection of morphological differentation among judo and ju-jitsu athletes? *Arch Budo*, 2014; 10: 67-73

Podstawski R, Choszcz D, Siemianowska E, Skibniewska KA. Determining the effect of selected anthropometric parameters on the time needed to cover 1000 m on a rowing ergometer by physically inactive young women. *Isokinetics and Exercise Science*, 2012; 20: 197-204. DOI: 10.3233/IES-2012-0459

Podstawski R, Honkanen A, Boraczyński T, Boraczyński M, Mańkowski S, Choszcz D. Physical fitness classification standards for Polish early education teachers. *South Afr J Res Sport Phys Edu Rec*, 2015; 37(1): 113-130

Podstawski R, Kasietczuk B, Boraczyński T, Boraczyński M, Choszcz D. Relationship Between BMI and Endurance-Strength Abilities Assessed by the 3 Minute Burpee Test. *Int J Sport Sci*, 2013; 3(1): 28-35

Podstawski R, Mańkowski S, Raczkowski M. The level of strength and endurance-strength abilities of the female early education teachers as examined by the Medicine Ball Forward Throw and the 3 Mininute Burpee test: a comparative analysis. *LASE J Sport Sci*, 2014; 5(2): 93-109

Podstawski R, Markowski P, Choszcz D, Żurek P. Correlations between anthropometric indicators, heart rate and endurance-strength abilities during high-intensity exercise of young women. *Arch Budo Sci Martial Arts Extreme Sport*, 2016a; 12: 17-24

Podstawski R, Markowski P, Choszcz D, Jarosław Klimczak, Romero Ramos O, Merino Marban R. Methodological aspect of evaluation of the reliability the 3-Minute Burpee Test. *Arch Budo Sci Martial Arts Extreme Sport,* 2016b; 12: 137-144

Podstawski R, Choszcz D, Konopka S, Klimczak J, Starczewski M. Anthropometric determinants of rowing ergometer performance in physically inactive collegiate females. *Biol Sport*, 2014; 31(4): 315-321

Sakamaki T. A study of the burpee push as a simple method of measuring endurance. *Nippon Ika Daigaku Zasshi*, 1983; 50(2): 173-190

Sanal E, Ardic F, Kirac S: Effects of aerobic or combined aerobic resistance exercise on body composition in overweight and obese adults: gender differences. A randomized intervention study. *Eur J Phys Rehabil Med,* 2013; 49: 1-11

Siska L, Brodani J. Use of Burpees in Combat Sports Conditioning Training – A Pilot Study. *IJSPE,* 2017; 3(4): 1-6. http://dx.doi.org/10.20431/2454-6380.0304001

Thompson WR. Worldwide survey of fitness trends for 2018. *ACSM's Health Fitness J*, 2017; 21(6): 10-19

Vidal Andreato L, Franzói de Moraes SM, Lopes de Moraes Gomes T et al. Estimated aerobic power, muscular strength and flexibility in elite Brazilian Jiu-Jitsu athletes. *Sci Sport,* 2011; 26: 329-337

Willis LH, Slentz CA, Bateman LA, Shields AT, Piner LW, Bales CW, Houmard JA, Kraus WE. Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. *J Appl Physiol,* 2012; 113: 1831-1837

**Corresponding author:**

**Robert Podstawski**
University of Warmia and Mazury in Olsztyn, Faculty of Environmental Sciences,
Department of Tourism, Recreation and Ecology, M. Oczapowskiego 5, 10-719 Olsztyn, Poland,
Phone 601 65 25 27,
E-mail: podstawskirobert@gmail.com